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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
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10/538,306

06/09/2005

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EXAMINER

ARORA, AJAY

ART UNIT

PAPER NUMBER

2811

MAIL DATE

DELIVERY MODE

01/03/2008

PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary

Application No.

10/538,306

Applicant(s)

UEKI ET AL.

Examiner

Ajay K. Arora

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-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED. (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) ☒ Responsive to communication(s) filed on 05 September 2007.
- 2a) ☐ This action is **FINAL**. 2b) ☒ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

- 4) ☒ Claim(s) 7-19 and 21-25 is/are pending in the application.
- 4a) Of the above claim(s) 7-16 is/are withdrawn from consideration.
- 5) ☐ Claim(s) _____ is/are allowed.
- 6) ☒ Claim(s) 17-19 & 21-25 is/are rejected.
- 7) ☐ Claim(s) _____ is/are objected to.
- 8) ☐ Claim(s) _____ are subject to restriction and/or election requirement.

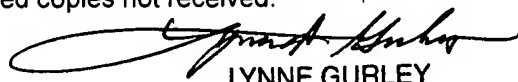
Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on _____ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.
- Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
- Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

- 12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All b) ☐ Some * c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
2. ☐ Certified copies of the priority documents have been received in Application No. _____.
3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.


LYNNE GURLEY
SUPERVISORY PATENT EXAMINER
AV2811, TC 2800

Attachment(s)

- 1) ☒ Notice of References Cited (PTO-892)
- 2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
- 3) ☐ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08)
Paper No(s)/Mail Date _____
- 4) ☐ Interview Summary (PTO-413)
Paper No(s)/Mail Date. _____
- 5) ☐ Notice of Informal Patent Application (PTO-152)
- 6) ☐ Other: _____

DETAILED ACTION

Continued Examination Under 37 CFR 1.114

A request for continued examination under 37 CFR 1.114, including the fee set forth in 37 CFR 1.17(e), was filed in this application after final rejection. Since this application is eligible for continued examination under 37 CFR 1.114, and the fee set forth in 37 CFR 1.17(e) has been timely paid, the finality of the previous Office action has been withdrawn pursuant to 37 CFR 1.114. Applicant's submission filed on 09/05/2007 has been entered. An action on the RCE follows.

Claim Rejections - 35 USC § 112

The following is a quotation of the second paragraph of 35 U.S.C. 112:

The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

Claims 17-19 and 21-25 are rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

Claim 17 recites (page 6, last two lines of claim 17) the limitation "the barrier metal at the interface between the barrier metal film and the polycrystalline copper alloy" (emphasis added). There is insufficient antecedent basis for this limitation in the claim.

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Whereas the claim previously recites a "barrier layer", the claim does not previously recite a "barrier metal film" or a "barrier metal at the interface between the barrier metal film and the polycrystalline copper alloy", and hence the reference to the barrier metal film or the barrier metal, as explained above, is not clear.

Claim 18 recites (page 7, see last two lines of claim 18) "the barrier metal at the interface between the barrier metal film and the polycrystalline copper alloy has not been oxidized" (emphasis added). Similarly, page 7, 4th last line of claim 18, recites "the oxide of the additional element" (emphasis added). There is insufficient antecedent basis for these limitations in the claim. The claim does not previously recite a "barrier metal film" or a "barrier metal" at the interface between the barrier metal film and the polycrystalline copper alloy, or an "oxide". Hence the reference to the barrier metal, the barrier metal film, or the oxide of the additional element, as explained above, is not clear.

Claim 19 recites (page 8, see last two lines of claim 19) "the barrier metal at the interface between the barrier metal film and the polycrystalline copper alloy has not been oxidized" (emphasis added). There is insufficient antecedent basis for these limitations in the claim. The claim does not previously recite a "barrier metal film" or a "barrier metal" at the interface between the barrier metal film and the polycrystalline copper alloy. Hence the reference to the barrier metal or the barrier metal film, as explained above, is not clear.

Claim Rejections - 35 USC § 103

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

Claims 17, 19, 21 and 25 are rejected under 35 U.S.C. 103(a) as being unpatentable over Andricacos et al. (IDS reference EP 0751567 A2), hereinafter Andricacos, in view of Wang et al. (2003/0217462), hereinafter Wang, and further in view of Bojkov et al. (US 2003/0116845), hereinafter Bojkov.

Regarding claim 17, Andricacos (refer to Figures 3) teaches a copper alloy for wiring (Col. 5, lines 31-36) formed by

forming a polycrystalline copper alloy comprising copper and an additional element (Col. 4, lines 14-16, Col. 5, lines 49-54 and Col. 6, lines 41-44), irrespective of whether the alloy is formed by the recited process steps or not (see explanation below), wherein

concentration of the additional element is, at grain boundaries of crystal grains composing the polycrystalline copper alloy and in vicinities of grain boundaries, higher than that of the inside of the crystal grains, a barrier layer (22) is formed to

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surround the polycrystalline copper alloy, and concentration of the additional element is, at the interface between the polycrystalline copper alloy and the barrier layer and in vicinities of said interface, higher than that of the inside of the crystal grains (Col. 6, lines 41-44).

However, Andricacos does not teach that the additional element that is diffused into the copper film via grain boundaries is at least one of the claimed group. Wang teaches a copper interconnect member wherein an additional element that is diffused into the copper film via grain boundaries is at least Zirconium (page 6, para 0057-0060). It would have been obvious to one of ordinary skills in the art at the time of the invention to modify the invention of Andricacos so that an additional element that is diffused into the copper film via grain boundaries is at least Zr (Zirconium). The ordinary artisan would have been motivated to modify Andricacos for at least the purpose of improved adhesion to subsequent layers (page 6, para 0060; also see page 5, para 0051).

Further, Andricacos does not specifically teach that "the barrier metal at the interface between the barrier metal film and the polycrystalline copper alloy has not been oxidized". Bojkov discloses that it is known in the art to form a copper contact with a barrier metal layer which may comprise Ni, and further an oxygen gettering layer (that may be Ti) between the copper contact and the barrier metal layer (page 3, para 0036), for the purpose of removing oxygen from copper (page 3, para 0033, last two sentences); i.e. preventing oxide formation in both the copper and the barrier metal

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layer. Therefore, it would have been obvious to one of ordinary skills in the art at the time of the invention to modify the device of Andricacos so that the barrier metal at the interface between the barrier metal film and the polycrystalline copper alloy has not been oxidized. The ordinary artisan would have been motivated to modify Andricacos for at least the purpose of forming more reliable attachment to copper when used as a contact (page 3, para 0033, last two sentences) or reduce the resistance of the copper contact.

Note that claim 17 is a product claim but parts of the claim recite process limitations. Examples of such process limitations include the specific process steps or sequence of process steps for forming the polycrystalline copper alloy, as recited in claim 17 (see applicant's claim 17 on page 5, last five lines,), or the use of a specific process (like "gettering") or its timing (as suggested by the limitation "simultaneously") in claim 17 (see page 6, lines 1-2). Therefore, these claims amount to product by process limitations, which will not be given patentable weight. *"Even though product-by-process claims are limited by and defined by the process, determination of patentability is based on the product itself. The patentability of a product does not depend on its method of production. If the product in the product-by-process claim is the same as or obvious from a product of the prior art, the claim is unpatentable even though the prior product was made by a different process." In re Thorpe, 777 F.2d 695, 698, 227 USPQ 964, 966 (Fed. Cir. 1985). See MPEP 2113.*

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Regarding claim 19, Andricacos (refer to Figures 3) teaches a copper alloy for wiring (Col. 5, lines 31-36) formed by

forming a polycrystalline copper alloy comprising copper and an additional element (Col. 5, lines 49-54 and Col. 6, lines 41-44), irrespective of whether the alloy is formed by the recited process steps or not (see explanation below), wherein

concentration of the additional element is, at grain boundaries of crystal grains composing the polycrystalline copper alloy and in vicinities of grain boundaries, higher than that of the inside of the crystal grains (Col. 6, lines 41-44), and concentration of the additional element in the crystal grains is 0.1 atomic percent or less (Col. 5, lines 49-53).

However, Andricacos does not teach that the additional element that is diffused into the copper film via grain boundaries is at least one of the claimed group. Wang teaches a copper interconnect member wherein an additional element that is diffused into the copper film via grain boundaries is at least Zirconium (page 6, para 0057-0060). It would have been obvious to one of ordinary skills in the art at the time of the invention to modify the invention of Andricacos so that an additional element that is diffused into the copper film via grain boundaries is at least Zr (Zirconium). The ordinary artisan would have been motivated to modify Andricacos for at least the purpose of improved adhesion to subsequent layers (page 6, page 0060; also see page 5, para 0051).

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Further, Andricacos does not specifically teach that “the barrier metal at the interface between the barrier metal film and the polycrystalline copper alloy has not been oxidized”. Bojkov discloses that it is known in the art to form a copper contact with a barrier metal layer which may comprise Ni, and further an oxygen gettering layer (that may be Ti) between the copper contact and the barrier metal layer (page 3, para 0036), for the purpose of removing oxygen from copper (page 3, para 0033, last two sentences); i.e. preventing oxide formation in both the copper and the barrier metal layer. Therefore, it would have been obvious to one of ordinary skills in the art at the time of the invention to modify the device of Andricacos so that the barrier metal at the interface between the barrier metal film and the polycrystalline copper alloy has not been oxidized. The ordinary artisan would have been motivated to modify Andricacos for at least the purpose of forming more reliable attachment to copper when used as a contact (page 3, para 0033, last two sentences) or reduce the resistance of the copper contact.

Note that claim 19 is a product claim but parts of the claim recite process limitations.

Examples of such process limitations include the specific process steps or sequence of process steps for forming the polycrystalline copper alloy, or the use of a specific process (like “gettering”) or its timing (as suggested by the limitation “simultaneously”) in claim 17 (as recited in claim 19 on page 7, last 9 lines). Therefore, these claims amount to product by process limitations, which will not be given patentable weight. *“Even though product-by-process claims are limited by and defined by the process,*

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determination of patentability is based on the product itself. The patentability of a product does not depend on its method of production. If the product in the product-by-process claim is the same as or obvious from a product of the prior art, the claim is unpatentable even though the prior product was made by a different process." In re Thorpe, 777 F.2d 695, 698, 227 USPQ 964, 966 (Fed. Cir. 1985). See MPEP 2113.

Regarding claim 21, Andricacos as modified above teaches that at the crystal grain boundaries and/or in the vicinities of grain boundaries, intermetallic compounds of Cu and at least one element (Zr) are formed. Note that an alloy of two metals is essentially an intermetallic compound of the two metals.

Regarding claim 25, Andricacos teaches the copper alloy for wiring wherein

concentration of the additional element at the grain boundaries and in the vicinities of grain boundaries is at least 120% of the additional element concentration at the inside of the crystal grains (Col. 3, lines 44-51), and further teaches that the concentration of the additional element at the grain boundaries and in the vicinities of grain boundaries may approach saturation (Col. 6, lines 41-44). It would have been obvious to one of ordinary skills in the art at the time of the invention to modify the device of Andricacos so that the concentration of the additional element at the grain boundaries and in the vicinities of grain boundaries is very high, such as on the order of 10 to 100 times the additional element concentration at the inside of the crystal grains. The ordinary artisan would have been motivated to modify Andricacos for at

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least the purpose of approaching saturation at the grain boundaries and in the vicinities of grain boundaries (Col. 6, lines 41-44) to improve wiring properties with respect to electromigration.

Claim 18 is rejected under 35 U.S.C. 103(a) as being unpatentable over Andricacos et al. (IDS reference EP 0751567 A2), hereinafter Andricacos, in view of Lee (US 5,552,341), hereinafter Lee, and further in view of Bojkov et al. (US 2003/0116845), hereinafter Bojkov.

Regarding claim 18, Andricacos (refer to Figures 3) teaches a copper alloy for wiring (Col. 5, lines 31-36) formed by

forming a polycrystalline copper alloy comprising copper and an additional element (Col. 5, lines 49-54 and Col. 6, lines 41-44), irrespective of whether the alloy is formed by the recited process steps or not (see explanation below), wherein

the additional element is at least tin (Col. 5, lines 31-36)

concentration of the additional element is, at grain boundaries of crystal grains composing the polycrystalline copper alloy and in vicinities of grain boundaries, higher than that of the inside of the crystal grains (Col. 4, lines 14-19 and Col. 6, lines 41-47), and

a barrier metal film (Ta, see Figure 3) is formed on the polycrystalline copper alloy,

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However, Andricacos does not disclose that "the oxide of the additional element are formed at said grain boundaries and/or in vicinities of said grain boundaries". Lee discloses alloy compositions for wiring, teaching that it is desirable to form an oxide on the surface of the diffusion barrier layer and in the grain boundary thereof (Col. 5, lines 66-67). It would have been obvious to one of ordinary skills in the art at the time of the invention to modify the device of Andricacos so that the oxide of the additional element are formed at said grain boundaries and/or in vicinities of said grain boundaries. The ordinary artisan would have been motivated to modify Andricacos for at least the purpose of improving effectiveness of the diffusion barrier (see Lee, Col. 6, lines 1-2).

Further, Andricacos does not specifically teach that "the barrier metal at the interface between the barrier metal film and the polycrystalline copper alloy has not been oxidized". Bojkov discloses that it is known in the art to form a copper contact with a barrier metal layer which may comprise Ni, and further an oxygen gettering layer (that may be Ti) between the copper contact and the barrier metal layer (page 3, para 0036), for the purpose of removing oxygen from copper (page 3, para 0033, last two sentences); i.e. preventing oxide formation in both the copper and the barrier metal layer. Therefore, it would have been obvious to one of ordinary skills in the art at the time of the invention to modify the device of Andricacos so that the barrier metal at the interface between the barrier metal film and the polycrystalline copper alloy has not been oxidized. The ordinary artisan would have been motivated to modify Andricacos for at least the purpose of forming more reliable attachment to copper when used as a

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contact (page 3, para 0033, last two sentences) or reduce the resistance of the copper contact.

Note that claim 18 is a product claim but parts of the claim recite process limitations.

Examples of such process limitations include the specific process steps or sequence of process steps for forming the polycrystalline copper alloy, as recited in claim 18 (see applicant' claims - page 6, last seven lines and page 7, 1st two lines), or the use of a specific process (like "gettering") or its timing (as suggested by the limitation "simultaneously" in claim 18 (see page 7, lines 1-2, of applicants claims). Therefore, these claims amount to product by process limitations, which will not be given patentable weight. *"Even though product-by-process claims are limited by and defined by the process, determination of patentability is based on the product itself. The patentability of a product does not depend on its method of production. If the product in the product-by-process claim is the same as or obvious from a product of the prior art, the claim is unpatentable even though the prior product was made by a different process."* *In re Thorpe*, 777 F.2d 695, 698, 227 USPQ 964, 966 (Fed. Cir. 1985). See MPEP 2113.

Claims 22-24 are rejected under 35 U.S.C. 103(a) as being unpatentable over Andricacos et al. (IDS reference EP 0751567 A2), hereinafter Andricacos, in view of Wang et al. (2003/0217462), hereinafter Wang, further in view of Bojkov et al. (US

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2003/0116845), hereinafter Bojkov, and still further in view of Lee (US 5,552,341), hereinafter Lee.

Regarding claim 22, Andricacos as modified above teaches substantially the copper alloy for wiring but does not teach that at the crystal grain boundaries and/or in the vicinities of grain boundaries, "oxides of at least one element selected from a group consisting of Ti, Zr, Hf, Cr, Co, Al, Ni, Mg, and Ag" are formed". Lee discloses alloy compositions for wiring, teaching that it is desirable to form an oxide on the surface of the diffusion barrier layer and in the grain boundary thereof (Col. 5, lines 66-67). It would have been obvious to one of ordinary skills in the art at the time of the invention to modify the device of Andricacos so that the oxide of the additional element are formed at said grain boundaries and/or in vicinities of said grain boundaries. The ordinary artisan would have been motivated to modify Lin for at least the purpose of improving effectiveness of the diffusion barrier (see Lee, Col. 6, lines 1-2) utilizing an existing metal layer to form the oxide.

Regarding claim 23, Andricacos (refer to Figure 3), as modified above, teaches a semiconductor device comprising a substrate (substrate of 26) on which a semiconductor element is formed, and a metal wiring (labelled Cu Alloy) composed of the copper alloy for wiring as set forth in any one of claims 17, 18, 19, 21 or 22.

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Regarding claim 24, Andricacos, as modified for claims 18, 19, 21 or 22, teaches the copper alloy for wiring in any one of claims 18, 19, 21 or 22, wherein

concentration of the additional element at the grain boundaries and in the vicinities of grain boundaries is at least 120% of the additional element concentration at the inside of the crystal grains (Col. 3, lines 44-51), and further teaches that the concentration of the additional element at the grain boundaries and in the vicinities of grain boundaries may approach saturation (Col. 6, lines 41-44). It would have been obvious to one of ordinary skills in the art at the time of the invention to modify the device of Andricacos so that the concentration of the additional element at the grain boundaries and in the vicinities of grain boundaries very high, such as on the order of 2 to 1000 times the additional element concentration at the inside of the crystal grains. The ordinary artisan would have been motivated to modify Andricacos for at least the purpose of approaching saturation at the grain boundaries and in the vicinities of grain boundaries (Col. 6, lines 41-44) to improve wiring properties with respect to electromigration.

Response to Arguments

Applicant's arguments filed 09/05/2007 have been fully considered.

Applicant's argument on page 11 and 1st paragraph of page 12, which do not specifically state what claim they are related to but talk about the invention as a whole, have been considered but are moot in view of the new ground(s) of rejection.

On page 12, applicant argues regarding claims 18 and 20, stating that Lee reference is not relevant because "Lee relates to grain boundaries of the barrier metal film" which prevents the main wiring material (Al) "from being diffused to the outside", but the present invention relates to "grain boundaries of the main wiring material and aims to suppress grain boundary diffusion of the main wiring material itself". This argument is not persuasive. Lee is not being utilized to teach suppression of grain boundary diffusion of the main wiring material itself, as that is taught by the primary reference Andricacos. Referring to (Col. 5, lines 66-67), Lee teaches that "It is desirable to form an oxide on the surface of the diffusion barrier layer and in the grain boundary thereof, in order to improve the characteristics of the diffusion barrier layer in the contact hole". The above teaching applies to any metal grain boundary and can hence be applied to Andricacos.

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Ajay K. Arora whose telephone number is (571) 272-8347. The examiner can normally be reached on Mon through Fri, 8am to 4:30pm.


If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Lynne Gurley can be reached on (571) 272-1670. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

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Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

AKA

Date: December 14, 2007


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